Journal of Learning Design

OVERCOMING THE GLASSY-EYED NOD: AN APPLICATION OF PROCESS-ORIENTED GUIDED INQUIRY LEARNING TECHNIQUES IN INFORMATION TECHNOLOGY

Trina Myers, Richard Monypenny
James Cook University, AUSTRALIA
Trina.Myers@jcu.edu.au, Richard.Monypenny@jcu.edu.au

Jarrod Trevathan
Griffith University, AUSTRALIA
J.Trevathan@griffith.edu.au

Abstract

Two significant problems faced by universities are to ensure sustainability and to produce quality graduates. Four aspects of these problems are to improve engagement, to foster interaction, develop required skills and to effectively gauge the level of attention and comprehension within lectures and large tutorials. Process-Oriented Guided Inquiry Learning (POGIL) is a technique used to teach in large lectures and tutorials. It invokes interaction, team building, learning and interest through highly structured group work. This paper describes a new approach to teaching Information Technology (IT) using POGIL. Two IT subjects were chosen for the implementation of the POGIL technique to explore its potential to resolve the aforementioned issues. Preliminary evidence from perspectives of the institution, students and lecturer suggest that POGIL is better able to maximise engagement, foster interaction and effectively gauge the level of attention and comprehension in teaching process-oriented IT concepts than a traditional didactic approach.

Keywords

POGIL, research-based education, active learning, information technology.

Introduction

The development of effective learning methods is essential to the sustainability of universities and the production of quality graduates. Sustainability is a complex challenge with endemic problems such as low student attendance in classes and decreasing retention rates. Universities must guarantee that students who graduate have the required disciplinary skills. This warrant requires successful student comprehension and application of disciplinary concepts, which can only be achieved through effective learning methods. Offering engaging quality courses can help. Obstacles to these challenges include class sizes, teaching allocations and the disconnect between the modern student and traditional teaching styles.

This paper outlines and provides evidence of success in addressing four significant challenges facing university lecturers in Information Technology (IT)—lecture attendance, large class sizes, rapid feedback of student comprehension, and the development of "soft skills" in IT. The first challenge is lecture attendance and how to improve engagement, interaction and interest in lectures of two to three hours. A major challenge in the development of pedagogical methods is how to

overcome the glassy-eyed stare and the empty nods seen in many lecture theatres. The traditional didactic approach of delivery is not effective—teaching by telling does not work (Bransford, 2000). Second is the continually increasing size of tutorial classes. In many cases, the ratio of a standard tutorial size of twenty-five students per tutor has expanded to 100:1 or higher. Smaller sizes usually create an intimate tutorial environment with interaction and discussion. The third issue is rapid feedback on how to effectively and instantaneously gauge the level of student comprehension in lecture and tutorial environments. The typical "nod" from students during lectures does not denote comprehension. Often there is a distinct disconnect between what would appear to be a full consensus of understanding in the lecture or tutorial and the results of tests on the content matter. The final issue is how to teach and how to give students experiences with "soft skills" in an IT degree. These skills are extremely important for IT professionals, but are often overlooked within the curriculum design and implementation (Chan, 2011).

Research into new developments and potential solutions for the teaching challenges above has led to the Process-Oriented Guided Inquiry Learning (POGIL) project (2011). POGIL is a pedagogical method devised in 1994 from cooperative and collaborative learning techniques to teach process skills (such as collaboration and written expression) as well as content using an inquiry-based approach (Moog & Spencer, 2008). The first implementation was at Franklin and Marshall College, Pennsylvania to first year chemistry students. Although POGIL employs student-centered techniques, it differs from other approaches in two ways. The first difference is the explicit and conscious emphasis on developing process skills and the second is the use and design of distinctive classroom materials. The materials have two significant defining characteristics: POGIL activities are created for use by self-managed teams consisting of highly structured roles; and the sessions guide students through an exploration to construct, deepen and refine comprehension of the content (POGIL, 2011). Currently this methodology is predominantly implemented in scientific disciplines and in particular Chemistry (Farrell, Moog, & Spencer, 1999). However, we have found that the method lends itself to the analytical problem solving nature of Information Technology (IT) and Computer Science.

This paper reports how POGIL was implemented and trialled over two years in two separate IT subjects at James Cook University. Descriptions are presented on how it was adapted for use in IT, the roles the students played as individuals and during group work, and how the lecturer took on the role of a learning facilitator. Preliminary empirical and anecdotal evidence is presented from the perspectives of the institution, students and the lecturer. The evidence supports the claims that POGIL can foster full engagement, it can help to develop interpersonal and oratory skills, and it can cultivate students' ability to analyse and synthesise information in a fun and open atmosphere.

This paper is structured as follows. Section 1 introduces the concepts and learning methods employed to increase interactivity and learning outcomes. Section 2 describes the motivations, methodology and implementation of POGIL within the IT classroom. Section 3 reports the quantitative and qualitative analysis of the first documented trial in the discipline of IT. Section 4 reflects on the methodology's potential in flexible curriculum delivery for IT courses that comprise analytical content. The paper concludes with a brief summary and implications for the future.

Motivations

Four of the many teaching problems being faced due to challenging pedagogy outcomes and/or budget constraints are: lecture attendance, large tutorial class size, student comprehension and disciplinary skills development. Firstly, lecture attendance and how to maximise engagement, interaction and interest in the two or three hours of lecture time periods. These periods are too long to effectively maintain attention, even with breaks. A common practice is to teach the major portion of a 50 minute lesson in the first 15 minutes because there is a limit to the attention span of students (Bedgood Jr et al., 2010; Benjamin Jr, 2002; McKeachie & Svinicki, 2006). So why do lecturers continue with the other 35 minutes? Clearly most of the content will not be absorbed and the result will be a lecture theatre full of glassy-eyed stares and empty nods from students who try to pay attention but have effectively "phased out" of the information flow (Wilson & Korn, 2007).

Research has shown students learn more when they construct their own understanding of concepts (Bransford, 2000; D. Hanson & Wolfskill, 2000; Postman & Weingartner, 1971).

Secondly, tutorial class size has increased considerably from the manageable traditional-sized groups of approximately twenty-five. Learning takes place in interactive environments, such as tutorials, where students can expand their understanding through collaborative work and lecturers can assess individual levels of comprehension to guide their teaching strategies. However, commonly due to budget constraints, the number of tutorials for subjects are being cut and the few remaining need to cater to a larger number of students. The challenge here is to create a large tutorial without losing the interaction that is vital to the tutorial learning environment.

Thirdly, mechanisms that gauge the level of student comprehension in a lecture environment at the time of concept introduction are highly conducive to pedagogy. Walker, Cotner, Baepler, & Decker (2008) have stated lectures are ineffective as an instructional strategy because they result in passive students. The passive student can be recognised by the arbitrary glassy-eyed nods during a lecture. Critics also state lecturers persist with the traditional one-way communication lecture method due to: the amount of content to be delivered in a short period of contact time; space and lecture theatre layout enrolment numbers; and teaching schedules (Lujan & DiCarlo, 2006). However, there are advocates of the lecture such as Burgan (2006) and Walker et al (2008), who believe students benefit from compelling oration. Walker et al (2008) stated there are two factors that most engage undergraduate students are control of material and concern that students understand the material. Walker et al (2008) went on to affirm the incorporation of active learning methods in conjunction with a traditional didactic approach could help to keep participants engaged and allow the lecturer to measure comprehension during the lecture.

Fourthly, the IT-specific challenge to initiate the development of the essential interpersonal skills (soft skills) required of IT professionals. These skills are often overlooked within the curriculum development of an IT degree with the focus predominantly on necessary hard skills. Exposure to forming professional relationships and the development of communication methods are imperative to the production of quality IT graduates (Bailey & Stefaniak, 2002; McMurtrey, Downey, Zeltmann, & Friedman, 2008). Stereotypically, interpersonal communication skills are not the focus of the IT enthusiast nor is it the focus within the IT curriculum; practice and nurture are required to finely hone these skills. The challenge is to introduce the students at the first year level to these skills in a natural group environment. The students can continue throughout their degree with mounting confidence and articulation to match their emergent IT skills through this early introduction of a team culture and initiation of basic interpersonal skills (Chan, 2011).

The POGIL and active learning methods appeared to be the answer to all of these four challenges. These instructional methods offer techniques that can engage all students during a lecture and simultaneously enhance the interpersonal skills of the IT students.

Non-didactic teaching methodologies

A “traditional didactic approach” is one in which the lecturer is the sole source of information during a lecture. There is a one-way exchange of information from the lecturer to the students. The students must take notes based on their interpretations of the material. There is little, if any, interaction in the form of students asking questions of the lecturer, being asked questions by the lecturer, or having students collaboratively working with each other. Research conducted into this teaching style suggests a disconnection with the way the human brain is wired to interpret new information and learn. The brain appears to have been designed to solve problems related to surviving in an unstable outdoor environment and to do so in near constant motion. Most modern classrooms and business cubicles are designed seemingly completely the opposite (Bransford, 2000).

Most students tend to lose focus after approximately 15 minutes during traditional didactic lectures (Postman & Weingartner, 1971). There is conflicting sentiment on what constitutes "low attention" and what its effects are on "knowledge retention" but the consensus is that attention spans will fluctuate throughout a lecture (Wilson & Korn, 2007). Therefore, a strong level of student engagement or participation is required to reduce the number and duration of "attention deficit" moments (Middendorf & Kalish, 1996). There are several pedagogical theories that deal specifically with student-focused learning and engagement.

Constructivism is one of the teaching theories behind student-focused learning (Bauersfeld, 1995). Theoretically, humans best generate knowledge and meaning through their interactions between experiences and ideas. The theory argues that students can only learn through "constructing" knowledge and instructors should adapt to the role of facilitators and not lecturers (Bauersfeld, 1995). Whereas a lecturer gives a traditional didactic lecture that covers the subject matter, a facilitator helps the learner achieve an understanding of the content. The learner plays an active role in the learning process rather than passive as in a traditional didactic approach (Ben-Ari, 1998; Walker et al., 2008).

Two other theories are Engagement Theory (Kearsley & Shneiderman, 1998) and Active Learning (Middendorf & Kalish, 1996). Engagement Theory follows the premise that all student activities involve active cognitive processes such as creating, problem solving, reasoning, decision-making, and evaluation. Students are intrinsically motivated to learn due to the meaningful nature of the learning environment and activities such as working in collaborative teams on ambitious projects that are significant outside the classroom. Similarly, Active Learning methods have students engage in the classroom with opportunities to practice with the relevant concepts during class (Middendorf & Kalish, 1996). These collaborative learning techniques are effective for reducing student passivity and getting students actively engaged by making the classroom a social learning experience instead of a solitary one.

POGIL is an emerging methodology based on elements of the above three theories (Farrell et al., 1999; D. Hanson & Wolfskill, 2000). POGIL was originally devised for use in teaching general chemistry, but its structure is broadly applicable in all subjects (D. M. Hanson, 2006).

POGIL lends itself to the analytical problem solving nature of IT and Computer Science. It is a student-centred strategy where students work in small groups with consistently structured individual roles to ensure that all students are fully engaged in the learning process (Bedgood Jr et al., 2010; POGIL, 2011). POGIL materials are designed for use by the self-managed groups and as they work, they interact with the lecturer as a guide rather than a "sage on the stage."

The POGIL materials guide students through an exploration to construct understanding. The activities compel the students to process information, verbalise and share their perceptions and understanding and to make inferences and conclusions (i.e., to construct knowledge) (D. Hanson & Wolfskill, 2000). The collective knowledge of the group is applied to exercises and problems that require higher-order thinking such as the synthesis, analysis and/or integration of ideas with previously learned concepts. The group work helps to develop process skills such as critical thinking, problem solving, and communication through cooperation and reflection, which can prepare students for the professional arena (Bransford, 2000; Moog & Spencer, 2008; Sharma & Bewes, 2011).

Methodology — The case study of two IT courses

To our knowledge, this paper is the first documented trial of POGIL in the discipline of IT. Two IT subjects, "Conceptual Modelling" and "Internet-working", were chosen to adopt and implement the teaching methodology. The first subject teaches conceptual modelling and data management concepts that are used to construct machine-processable schemata about corporeal world entities for deployment in data and knowledge systems. The second subject introduces Internet-working protocols, architectures and technologies. The syllabus concepts in both subjects are process based

and cumulative in nature and therefore appropriate to process-oriented instruction. POGIL techniques were incorporated into the current curriculum by interweaving structured group work as part of both the tutorials and lectures. The integrated group work initiated discussion, interest and the development of the students' interpersonal skills and made possible the necessary feedback on comprehension.

Building the POGIL culture

The culture of "group work with attitude" was developed at the onset of each subject and was imperative to expectation management. The ethos entails that students understand the following:

1. The benefits from using POGIL in the subject. This is achieved though fun exercises that effectively prove to students the advantages of shared information and collaborative learning.

2. The rules and roles of the highly structured group sessions. Consistency and timing is required to instill seamless transitions to and from groups to maximise productivity within the sessions. Time is often wasted in the setting up of groups, keeping groups focused and the transit back to lecturer-centric mode with standard pedagogical group work.

3. Expectation for each session. What responsibilities are expected for each POGIL instance through consistent adherence to the rules of the highly structured group sessions.

The basic rules of the highly structured POGIL group sessions entail that students work together in groups of three or four and are assigned a role as either "Manager", "Recorder", "Presenter" or "Reflector" (optional). Importantly, each role is dependent on the other roles so students are accountable to their peers for the role they play. The Manager ensures that team members are fulfilling their roles, accomplishing the assigned tasks on time, and all members of the group are participating in the activities and understanding the concepts. The Recorder scribes the group's discussions and important aspects of the group's observations, insights and the significant concepts learnt. The Presenter delivers oral reports to the class in a concise manner with time limits if required. Importantly, the Manager must ensure the Recorder is taking appropriate notes as the Recorder's notes are used by the Presenter to present as required. The Reflector observes group dynamics, behaviour and performance and may be called on to report to the group (or the entire class) about how well the group operates (or what needs improvement). The students work together on activities that are structured to help them build knowledge of a concept and are expected to reach a consensus answer to communicate in written or oral form. Importantly, the group members and roles change for each class to avert stagnating routines.

Our strategy was to build a culture of POGIL group work from the beginning of the courses and consistently maintain the format throughout the semester. POGIL was introduced in week one with an exercise to dramatically show the benefits of combining knowledge with peers versus individual work. The exercise entailed each student work alone to draw a diagram specified by the lecturer (the diagram consisted of shapes from different disciplines such as mathematical functions, pictographs, geometric shapes, icons, signs, etc.). They were then asked to indicate their confidence level on their diagram's accuracy, which was predictably low. At this stage, the lecturer introduced POGIL and its benefits, rules and roles to the class. The students then formed groups for the first time and once the roles were set, the lecturer repeated the exercise. This time, when the class were asked to assess their confidence of correctness the result was predictably much higher than as individuals. This method of introduction dramatically showed the students the benefits of shared knowledge and collaborative learning and was extremely effective in laying a cultural foundation for the succeeding subject-related group work.

POGIL sessions were interwoven into the syllabus each week throughout the semester. There was adequate time for three to five POGIL sessions weekly within the lecture and tutorial periods for each subject. These sessions were initiated at timely intervals to coincide with waning attention

spans. The POGIL tasks included directed, convergent or divergent questions. Directed questions can be answered directly from the information provided, convergent questions require groups to reach a consensus of the solution, and divergent questions can have a range of possible responses which can all be correct (Moog & Spencer, 2008). The POGIL tasks were strategically placed within the pedagogical design to support the learning cycles (Moog & Spencer, 2008). Initially, the lecturer introduced the lesson's concept and terms. Then, depending on the content and learning aim, a POGIL directed, convergent or divergent question followed. The lecturer could then roam the room and assess comprehension. The students found where the gaps in their knowledge lay during this first task because in most cases the tasks were carried out without prior "in-depth" instruction. Then, "snapping back" to lecturer-centric mode, the lecturer could add more depth to the topic, at which stage students were more attentive and open to fill the now conscious deficit in knowledge. At this stage, often a second more complex POGIL exercise was introduced to further assess the comprehension of the class. The lecturer could effectively and instantaneously gauge the level of student comprehension and at this point they could modify the lecture depending on the cognition of the class.

Group formation and evolution

Group membership was determined randomly for both subjects early in the semester (weeks 1–3). The random allocation appeared to work extremely well when all in the group were either strangers or not from the same clique. An unexpected added benefit was the formation of a community as a whole. Group membership and roles were changed each class, which simultaneously took all students out of their respective comfort zones. The forced introduction to strangers was experienced by all students. These shared social predicaments were faced as a community so the bonds formed early in the semester.

The groups' memberships evolved as the lecturer gained knowledge of the individual personalities, abilities and level of understanding in the early weeks (1–3) of the semester. This knowledge made possible the creation of groups based on the capabilities of participants. The familiarity of students as individuals combined with knowledge of their aptitude, leadership tendencies and capabilities allowed the lecturer to group students based on a range of criteria. For example, some of the specific criteria used to strategically match group members were the student's grasp of the subject content, their level of interpersonal skills, their abilities to manage a group or to be managed. Then POGIL activities were fashioned to challenge the groups at either intermediary or advanced levels. Further, groups could be formed with a mix of intermediary and advanced students and given generic exercises; the advanced students acted as tutors within their groups. The rationale of introducing an advanced student to a less advanced group dynamic was to foster a mentor environment. The confidence and knowledge of the advanced students increased because they were required to articulate the concepts verbally to the other group members.

Preliminary evidence

This section presents empirical and anecdotal evidence from the perspectives of the institution, the student and the lecturer to gauge the success of POGIL group work in IT. The Student Feedback on Teaching (SFT), Student Feedback Survey on subjects (SFS) (provided at the institutional level) and an in-class midterm survey (prepared by the lecturer) included both quantitative and qualitative response fields. Student evaluations of the subject and of teaching included items such as overall teaching ability, knowledge of subject, respect and concern for students, learning outcomes and the course overall. Table 1 presents the student and institutional perspective. The semesters where traditional delivery was employed (2008, 2009) and semesters where POGIL was initiated (2010, 2011) can be compared based on the relevant feedback questions. Importantly, the semesters that incorporate POGIL had substantially higher results in the pertinent criteria than the semesters that used traditional delivery methods, which implies this method is a causal factor in

the improvement. Specifically, improvement in problem solving skills (increase of 12%), the interest generated within the subject (increase of 34%) and lecturer explanations (increase of 32%) are highly significant to the motivating factors of this research. This evidence supports the claims that POGIL can foster full engagement, it can help to develop interpersonal and oratory skills, and it can cultivate students' ability to analyse and synthesise information in a fun and open atmosphere.

Although the evidence appears to link the causal factors to the change in pedagogy, the analysis could be viewed as subjective. However, the data gathered around student learning outcome is predominantly objective. Future research will help clarify this point. We have planned studies on improved measurement techniques to better gauge the causal impact POGIL has on learning outcomes.

Table 1. *Comparison of traditional delivery methods versus POGIL—Student Feedback Survey on subjects (SFS) for Conceptual Modelling 2008—2011*

Conceptual Modelling—relevant survey questions Highest ranked average is 5	2008 Traditional delivery	2009 Traditional delivery	2010 POGIL	2011 POGIL
The teaching staff of this subject motivated me to do my best work	3.8	3	4.2	4.3
The teaching staff worked hard to make this subject interesting	3.4	2.8	4	4.5
My lecturers were extremely good at explaining things	2.4	2.8	4	4
The staff made it clear right from the start what they expected from students	3.8	2.8	4.1	4.2
The teaching and learning experiences of this subject were well organised	3.8	3.3	4	4.3
This subject developed my problem solving skills	NA	3	4.2	4.1
As a result of this subject, I feel more confident about tackling unfamiliar problems	NA	3.6	4	4.1
This subject helped me develop the ability to plan my work	NA	3	4	4.1

Figure 1 shows the quantitative results from the POGIL-specific midterm survey. The survey entailed three questions to gauge productivity in learning process style concepts, the benefits of learning difficult concepts via a traditional delivery versus POGIL, and the individual's development and understanding of the subject's concepts. The results indicate a positive consensus toward POGIL with over 85% of the students surveyed concurring POGIL is conducive to learning.

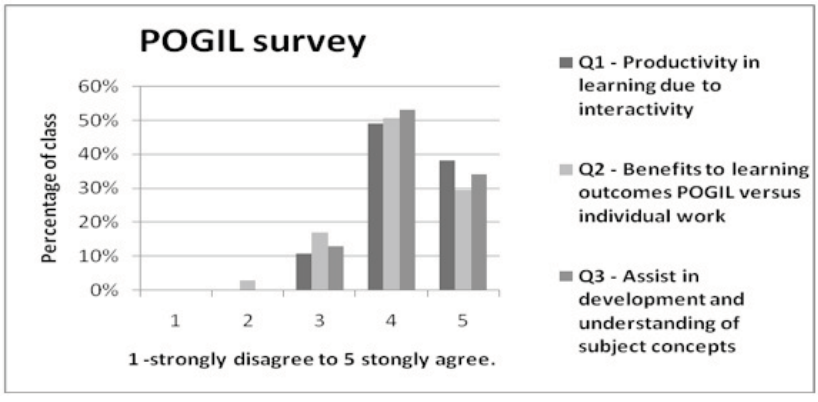

Figure 1. Survey results indicate IT students found POGIL beneficial to their studies (*n*=142)

The SFS, SFT and in-class POGIL survey each allowed for anecdotal comments from the student's perspective. The comments on POGIL group work in lectures all followed a similar trend that could be categorised as: a positive comment on the use of groups in lectures; the development of interpersonal skills; the accountability to fellow students; and/or the conscious awareness of comprehension during the sessions (Table 2).

Table 2: *The student's perspective—anecdotal comments on POGIL from students extracted from the midterm in-class survey, the SFS and SFT from 2010 and 2011*

Trends	Examples of Students' Comments
The use of POGIL groups in lectures and tutorials	• *Shared Knowledge! Different perspectives!* • *Teaching methods and flexibility allows me to learn in a more socially constructive way which suits my learning style. Group learning works so well* • *I don't zone out for the entire class. You get different opinions and ideas, if you're not really getting it someone in your group does. Get to meet everyone"* • *"Break from spoken material - reinforcing topics*
The development of interpersonal skills	• *Meet interesting people, sharing ideas to discuss and solve problems together* • *We can get to work ourselves, not just listen - Meet and work with people* • *Allows to know everyone each time in a new group. Positive environment in the class. Active concentration*
The accountability to fellow students	• *Learning from others. Being forced to be productive. Exposure to other members talents* • *Ability to get feedback from other team members and bounce ideas off each other*
The conscious awareness of comprehension during the sessions	• *The interaction between students aids us to gauge where we are at* • *Easier to learn the material* • *Good way to pick up different ideas* • *Collaboratively use our knowledge to form a reasonable response* • *Allows you to truly find out what you know by getting feedback from others*

During the second semester of 2011, a Peer Review of Teaching (PRoT) was conducted to gain a lecturer and the institution perspective. Two colleagues from different fields of expertise—Education and Veterinary Science—were assigned as reviewers. The review results were extremely positive—both reviewers saw benefits that could be incorporated in their own classes, particularly in Veterinary Science that entails a great deal of process-related content. Some specific comments included:

> *During this POGIL session there was a very positive atmosphere in the lecture room with nobody appearing to be disengaged. The reviewee was very effective at providing individualised responses to groups, and was constantly engaged with and in the student body... the inclusion of POGIL into lecturing can be highly motivational and inspired students to act collaboratively towards a common outcome. The reviewee ably integrated POGIL, with very positive effect. Students were highly engaged with the tasks and with the reviewee, and displayed high levels of motivation and engagement ... by the third or fourth session, they appeared to get into their groups relatively quickly and smoothly, and importantly seemed to regard this as a bit of fun. At no stage did I feel that this sense of fun detracted from the overall lecture...POGIL sessions are a very positive contribution to Information Technology; they are student-centered and they appear to be fostering a wider set of life skills than simply those associated with the immediate subject material.*

Implications

The above evidence from our trial of POGIL in the discipline of IT supports five implications:

Increased engagement: POGIL techniques have proven to be another constructive way to increase engagement, attain rapid feedback on student comprehension and develop "soft skills" during lectures and large tutorial classes. Tutorials can potentially be large without losing the interaction and discussion. The lectures incorporating POGIL are a hybrid of the traditional didactic and active learning techniques (i.e., traditional lectures versus tutorials). The students acknowledge the benefits they experienced from the guided enquiry learning environment and have indicated a preference to the continued development of the method within the IT curriculum.

An effective learning environment: Our trial of POGIL created a learning environment that combined the important functions of the lecture with the advantages of tutorial group work. Lectures provide explanation of difficult concepts and add value to the subject content readings. In contrast, tutorials invoke discussion of these concepts to reiterate the fundamentals for a higher level of comprehension. Our POGIL group tasks were integrated into the lectures before and after the lecturer introduced and explained new concepts to effectively combine theory and practice.

An opportunity to gauge student comprehension and dynamically modify content delivery: The integrated group tasks offered an immediate gauge of individual student comprehension, which is indispensable information to a lecturer. In practice, the lecturer cannot query each individual to measure his or her comprehension during a lecture. However, POGIL exercises offer an opportunity to gather this information. Then, the lectures can be dynamically modified to cater to the level of understanding of the class, which is conducive to the student overall learning evolution. The "on-the-fly" modification of content delivery is possible because the group tasks allow periods where the lecturer can roam amongst groups to check the group's functionality, their communications and their work. If a majority of groups did not successfully complete a task the lecturer can immediately alter the lesson to spend more time on that subject or concept. At this point students appear more attentive and open to the details and elucidation of the topic.

Improved inter-relationships within the classroom improve interpersonal skills: The integration of POGIL within the curriculum allowed almost immediate rapport between lecturer and each individual student and between the students themselves. The inter-relationships between students and student/lecturer were enhanced to a level not usually possible in the early weeks of a semester. The class evolved quite rapidly into a community as opposed to isolated individuals or cliques because the group membership, and the roles within groups, changed regularly. This evolution evoked open discussions, laughter and a comradely culture that became overt from an early stage of the semester. The inter-class group exercises cultivated interpersonal skills. Students who would normally not interact at all in class felt comfortable from the beginning of the semester to engage in interaction activities with others.

Improved retention: A closer student/lecturer relationship, which can positively influence student retention in first year students, is very difficult with the traditional didactic lecturing form of delivery. Students who feel disassociated from class and lecturers do not achieve the same confidence levels as those who interact with fellow student and lecturers, which can negatively affect attrition. POGIL work in the first year can positively influence retention rates because the lecturer is able to form a relationship with individual students early in the semester.

Future work could incorporate POGIL to non-attendance modes of subject delivery, explore better methods to gauge POGIL success on pedagogy outcomes and include a trial on the scalability of POGIL to even larger class sizes.

References

Bailey, J. L., & Stefaniak, G. (2002). Preparing the information technology workforce for the new millennium. *ACM SIGCPR Computer Personnel, 20*(4), 4-15.

Bauersfeld, H. (1995). The structuring of the structures: Development and functioning of mathematics as a social practice. In L. P. Steffe & J. Gale (Eds.), *Constructivism in education* (pp. 137-144). Hillsdale, New Jersey: Lawrence Erlbaum Associates Publishers.

Bedgood Jr, D. R., Gardiner, M., Yates, B., Bridgeman, A. J., Morris, G., Buntine, M., Mocerino, M., Southam, D., Pyke, S. M., & Lim, K. F. (2010). The development of teaching skills to support active learning in university science (ALIUS). *Journal of Learning Design, 3*(3), 10-19.

Ben-Ari, M. (1998). Constructivism in computer science education. *SIGCSE Bull., 30*(1), 257-261.

Benjamin Jr, L. T. (2002). Lecturing. In S. F. Davis & W. Buskist (Eds.), *The teaching of psychology: Essays in honor of Wilbert J. McKeachie and Charles L. Brewer* (pp. 57-67). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Bransford, J. (2000). *How people learn: Brain, mind, experience, and school*. Washington, D.C.: National Academies Press.

Burgan, M. (2006). In defense of lecturing. *Change: The Magazine of Higher Learning, 38*(6), 30-34.

Chan, V. (2011). Teaching oral communication in undergraduate science: Are we doing enough and doing it right? *Journal of Learning Design, 4*(3), 71-79.

Farrell, J. J., Moog, R. S., & Spencer, J. N. (1999). A guided-inquiry general chemistry course. *Journal of Chemical Education, 76*(4), 570.

Hanson, D., & Wolfskill, T. (2000). Process workshops - A new model for instruction. *Journal of Chemical Education, 77*(1), 120.

Hanson, D. M. (2006). *Instructor's Guide to Process-Oriented Guided-Inquiry Learning*. Lisle, IL: Pacific Crest.

Kearsley, G., & Shneiderman, B. (1998). Engagement theory: A framework for technology-based teaching and learning. *Educational technology, 38*(5), 20-23.

Lujan, H. L., & DiCarlo, S. E. (2006). Too much teaching, not enough learning: what is the solution? *Advances in Physiology Education, 30*(1), 17-22.

McKeachie, W. J., & Svinicki, M. (2006). *McKeachie's teaching tips: Strategies, research, and theory for college and university teachers (12th ed.)*. Boston: Houghton-Mifflin.

McMurtrey, M. E., Downey, J. P., Zeltmann, S. M., & Friedman, W. H. (2008). Critical skill sets of entry-level IT professionals: An empirical examination of perceptions from field personnel. *Journal of Information Technology Education, 7*, 101-120.

Middendorf, J., & Kalish, A. (1996). The “change-up” in lectures. *National Teaching and Learning Forum, 5*(2).

Moog, R. S., & Spencer, J. N. (2008). *Process Oriented Guided Inquiry Learning (POGIL)*. USA: American Chemical Society, Oxford University Press.

POGIL. (2011). *Process-oriented guided inquiry learning*. [Online]. Available: http://pogil.org/ (10 September, 2011).

Postman, N., & Weingartner, C. (1971). *Teaching as a subversive activity* London, UK: Penguin Books Ltd.

Sharma, M. D., & Bewes, J. (2011). Self-monitoring: Confidence, academic achievement and gender differences in physics. *Journal of Learning Design, 4*(3), 1-13.

Walker, J. D., Cotner, S. H., Baepler, P. M., & Decker, M. D. (2008). A delicate balance: integrating active learning into a large lecture course. *CBE-Life Sciences Education, 7*(4), 361-367.

Wilson, K., & Korn, J. H. (2007). Attention during lectures: Beyond ten minutes. *Teaching of Psychology, 34*(2), 85-89.

Acknowledgments
The authors would like to acknowledge and thank the students of James Cook University for their participation in the introduction of POGIL. Their enthusiasm is truly inspirational. We also thank our colleagues for their valuable feedback, suggestions and contribution during the peer review of teaching.